A NEW ORE OCCURRENCE IN THE ENVIRONMENT OF NAGYGALYA, NAGYLIPÓT AND ARANYBÁNYAFOLYÁS, MÁTRA MOUNTAINS, NE-HUNGARY

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SUMMARY

As a result of an ore geological survey in 1955 and 1956, the outlines of a new ore zone emerge south and southwest of Nagygalya Peak, Mátra Mountains. The ore traces are partly connected with silicified and carbonatized zones of vein-like shape: however, impregnations and disseminations of ore also occur. The observations have up to now demonstrated at least four zones of NW—SE strike, which may be, as suggested by scarce outcrops, connected by transverse veins of lower-temperature hydrothermal formation.

The ore-bearing zone was developed in the lower levels of the stratovolcanic framework of the Mátra Mountains, not having reached the so-called second lava flow, forming the bulk of the Mátra Mountains. This latter consists of a more or less uniform augite andesite, while the underlying first lava flow consists of differently decomposed varieties of a hypersthene andesite which can readily be classed according to a new rock system by Professor E. Szádeczky—Kardoss.

The stratovolcanic structure of the area is made up of the following formations:

1. Augite-andesite lava flow 2. Andesite dikes of variable composition	Upper Tortonian-Sarmatian
3. Ore veins 4. Silicified veins 5. Hypersthene andesite and its decomposed varieties 6. (Pseudo) agglomerate 7. II. rhyolite tuff 8. Rhyolite tuff with agglomerate 9. Grey and greyish-yellow sandstone	Tortonian stage
10. Grey to greyish-green "Schlier" 11. I. rhyolite tuff 12. Sandstone	Helvetian stage
13. Cross-stratified sandstone 14. Coarse conglomerate	Burdigalien stage
15. Glauconitic sandstone 16. Grey clay marl	Oligocene

The ore-bearing veins are generally of three sorts:

a) carbonatic-silicic ore-bearing veins,

b) highly crystalline ore veins with quartz druses,

c) silicic veins of greyish colour with chalcedony and opal, indicating low-temperature development.

Ore microscopy and X-ray analysis have shown the mineral association of the veins to be as follows :

ore minerals:	*gangues:*
native gold	quartz
chalcopyrite	amethyst
sphalerite	fluorite
galena	baryte
pyrite	
tetrahedrite	
tetradymite	
bismuthite	
tellurite	
native tellurium	
Pb-Zn-ochre	
smithsonite ?	

The new ore occurrence belongs, according to its elemental association, to the genetical system of the long-known Gyöngyösoroszi ore deposit, which, in i ts turn, belongs to the structural unit of the Western Mátra Mountains. The latter is divided by a large fault of NE—SW strike from the East Mátra Mountains ore area, which is characterized by a totally different element and mineral association.

The differences between the two ore formations are retraced to structural features of the basement and to the regeneration of ancient ore formations.

The petrographical and ore geological survey of the named area was carried out, together with hand-instrument mapping, in the summers of 1955 and 1956. In the course of this work such problems were chiefly attacked, the solution of which promised to shed some light on the hitherto almost untouched interrelation between hydrothermal alteration and ore genesis, and to yield a basis for eventually planning mining operations on this ore.

The investigated area is bordered towards the North by the Nagygalya crest, towards SE by the line Rudolftanya—Parádsasvár, and by the Mátraháza—Parád highway, towards SW by the line Kisgalya—Körösnyaktető and by the concurrence of Aranybányafolyás and Szénpatak valleys. It is made up by a rock series consisting of andesite and its so-called "mantle formation", which was, in lack of more detailed investigations, considered by J. Noszky Sen. to be a "metamorphosed" series and identified by him with the hydrothermally altered rocks occurring around the Gyöngyösoroszi ore veins.

In the course of the building of the new highway to Galyatető Peak, F. Papp (1935) observed in the newly-opened exposures a silification of some intensity in the environment of Kislipót, Nagylipót and Kisgalya (?) peaks. According to his findings, silicification has thoroughly altered the tuff and a rock he termed dacite, resulting in the formation of hydroquartzite, with chalcedony and phenocrysts of "rock crystal" in the cavities. In silicified tuff he occasionally found tridymite. The kaolinitic decomposition of the rocks he found to be prevailing in "dacite" and tuff underlying pyroxene andesite. He identified by macroscopic observation his "dacite" with the amphibole andesite of Vörösvár, Fehérkő and Lahóca (?) Peaks, containing the more acid members of the feldspar family as well as quartz. He also thought to have recognized in them some features of the Börzsöny Mountains amphibole dacite and of the Nagybánya (Transylvania) dacite as well.

In 1936, F. Papp observed intense silicification in the area between Nyesettvár, Nagylipót and Nagylápa. Hydrothermal alteration has most intensely touched an "amphibole-dacitic" rock (?) containing locally rich catterings of pyrite. As a summary hes tated that the propylitization, kaolinitization and the presence of pyrite in the area warrant an exploitation by mining only if the named sulphide disseminations prove to contain precious metals.

J. Mezősi has, by petrological investigation and mapping, shown that the hydrothermally altered varieties of andesite, cropping out on Galyatető, Mogyorósorom and Lápafő peaks, are differently decomposed products of a pyroxene andesite cropping out in the deeper gorges of the Aranybányafolyás valley. The feldspars of the rock are kaolinitized, their one-time presence is in some instances but indicated by calcite fillings. In his opinion the coloured constituents — presumably hypersthene and different sorts of augite — were altered into serpentine. In one hardly altered rock of greenish tint he has established the presence of 2,94 per cent of pyrite.

According to J. Mezősi there is no indication at all of significant ore enrichment, excepting the pyrite impregnations, as the hydrothermal alteration has led to dissemination of scarce pyrite, to kaolinitization and precipitation in some instances of calcite, and the precious metal content of pyrite cannot under such circumstances be significant.

The quartzite cone of the Asztagkő Peak, touching the southern border of the mapped area, held by J. Noszky Sen. to be the result of ancient geyser activity, and the adjoining quartzite crest of NNE-SSW strike, were considered by G. Szurovy to be a hydrothermal formation identical with the sulphide veins of Gyöngyösoroszi (18). He demonstrated the presence of sphalerite, pyrite and marcasite, antimonite, baryte, quartz, tridymite and, more recently, of galenite, cervantite and calcite.

The mapping apart and delimitation of the andesite varieties in the field has presented great difficulties and up to now it was carried out on rather general lines only. It was deemed sufficient to call the rocks hydrothermally or exogenetically altered, without attempting to indicate more accurately the process of alteration by nomenclature. A great advance was made in this field by the introduction of the new system of rocks established by E. Szádeczky—Kardoss as a result of investigations in the Mátra Mountains. This system makes possible to distinguish and genetically define the altered varieties of magmatic rocks and it gives quite a new basis for delineating the magma-geological structure of any given area.

Geological build of the area

The stratigraphical and stratovolcanic structure of the area is analyzed in the pertinent work of J. Noszky Sen. and P. Rozlozsnik. They have dealt with the progress of sedimentation in the area, the fitting of the Miocene sediments into the general outlines of Miocene stratigraphy, in a manner which is in complete harmony with our present-day knowledge, so that in the present paper we will consider these problems only inasmuch as is necessary to give an insight into the general geological structure of the area.

The oldest formation of our area is the dark grey to greenish grey clay marl occurring in the deeper gorges cut into the Parádsasvár crest, the upper parts of the marl gradually passing into a psammitic series. These sediments represent, according to J. Noszky Sen. and P. Rozlozsnik, the Rupelian and Chattian stages of the Oligocene. A full profile of the Neogene

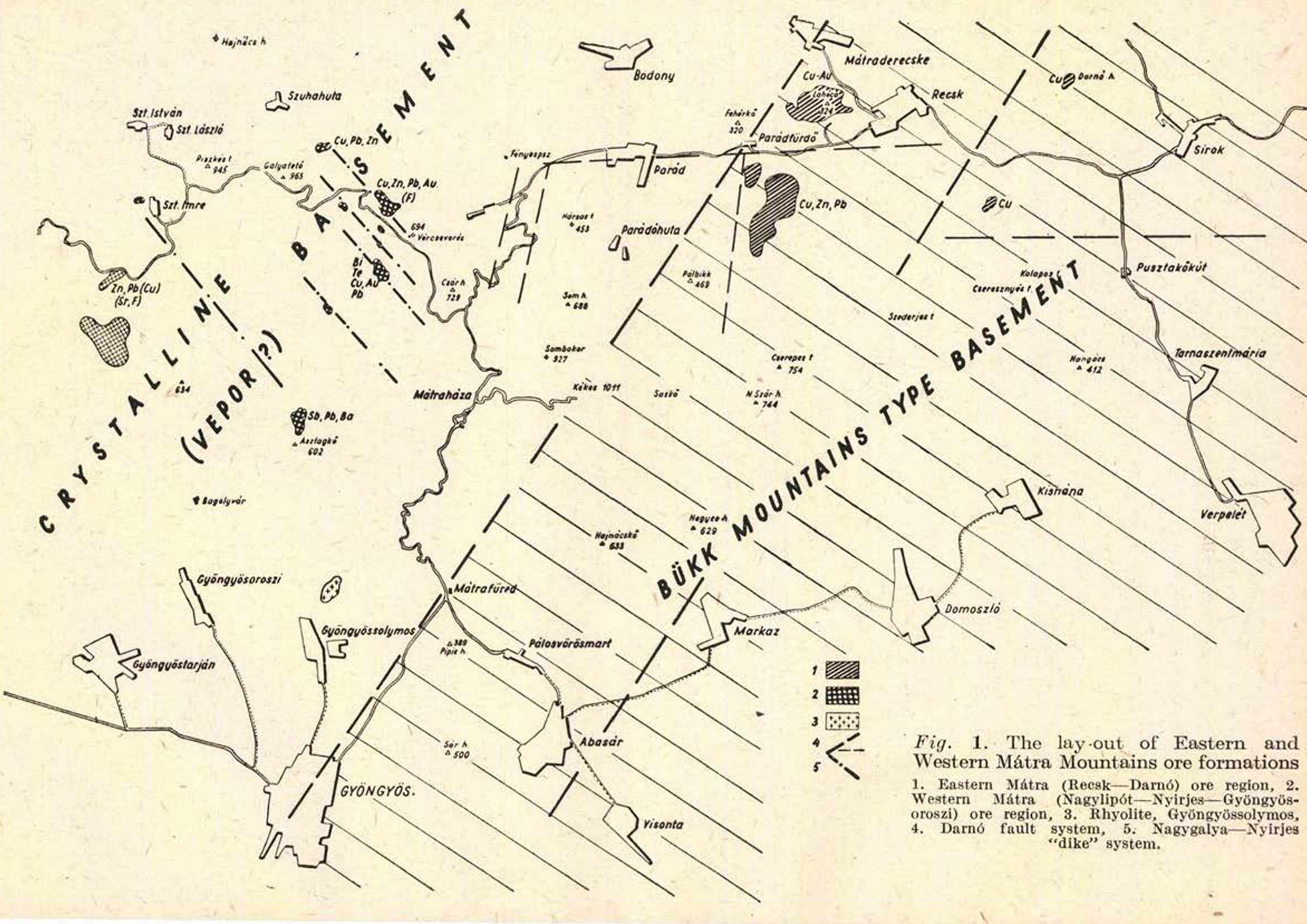


Fig. 1. The lay-out of Eastern and Western Mátra Mountains ore formations

1. Eastern Mátra (Recsk—Darnó) ore region, 2. Western Mátra (Nagylipót—Nyirjes—Gyöngyösoroszi) ore region, 3. Rhyolite, Gyöngyössolymos, 4. Darnó fault system, 5. Nagygalya—Nyirjes "dike" system.

marine and pyroclastic sequence is seen in the valleys of the Köszörü and Vészes Creeks running along the border of our area (Fig. 1). As seen there, above the greenish-grey clay marl and the Chattian sandstone, of quite subordinate thickness in the Vészes Creek profile, there follows with a hardly recognizable angular unconformity a coarse conglomerate of fist-size boulders, passing upwards into a cross-stratified sandstone having a double-peak grain size distribution characteristic of fluvial sands. This formation opens up a new cycle of sedimentation, that of the Burdigalian stage, closed by the socalled "lower rhyolite tuff", lying on the top of these sands. The rhyolite tuff gradually develops from the sandy series, with a dip identical at first (210/31°), then slowly changing into a southerly one. Above the tuff there is a bank of coarse conglomerate of 1—2 metres thickness, dipping 8° towards 195°, which upwards becomes alternately sandy and clayey-foliated, with dips in the southwestern sector (235/4°). Here the rock becomes intensely micaceous. With this series, consisting in its bulk of detritic material, begins the Helvetian which consists of 150 to 160 metres of the so-called Schlier. Around the middle of the same there is a tuffaceous interbedding, containing as much as 24,17 per cent of pyrite. Above, the series becomes somewhat sandy, continuing later in the previous clay marl facies of conchoidal fracture. Around the top of this series silicified wood debris, awaiting further study, is very frequent, with trunks of some metres length (in the valleys of Vészes and Csevice creeks). Above the Schlier a relatively loose yellow — reddish-yellow sandstone represents the first member of the Tortonian sedimentary cycle. Above, the sequence consists exclusively of pyroclastites: of tuffy agglomerate, passing gradually into a biotite-rich, pumice-bearing so-called

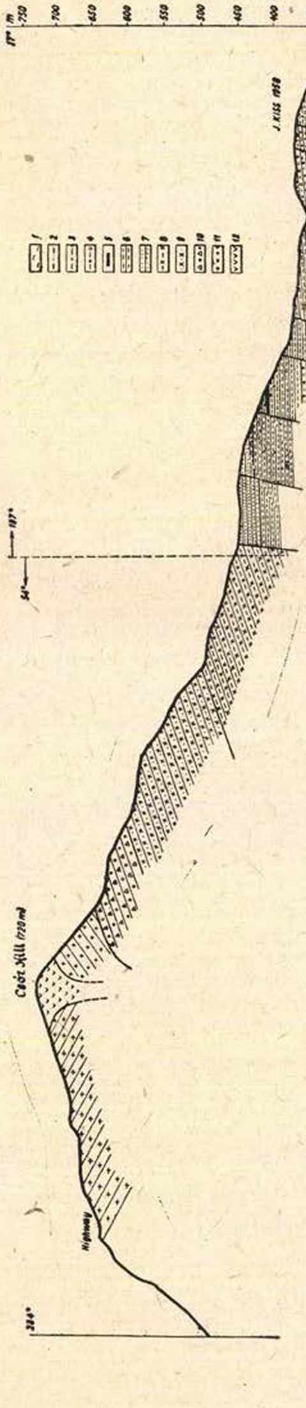


Fig. 2. Geological profile through Vészes Creek

1. Middle and upper Oligocene marl and sandstone, 2. Burdigalian sandstone and conglomerate, 3. Burdigalian rhyolite tuff; Helvetian, 4. Conglomerate and sandstone, 5. Pyrite, 6. Schlier; Tortonian, 7. Sandstone, 8. Agglomeratic tuff, 9. No II rhyolite tuff horizon, 10. Pseudoagglomerate, 11. Augitic hypersthene andesite. Sarmatian (?), 12. Hypersthenic augite andsite.

middle rhyolite tuff, containing relatively few andesitic detritus. This becomes again agglomerate-like around the top, and melts into the "pseudoagglomerate" of Csórhegy—Bagolykő—Vércverés peaks. The different varieties of andesite, occurring in morphologically characteristic dikes and lava-flows, have broken through this latter pseudoagglomerate.

As was seen above, the volcanic activity in the area treated has commenced with an acid magma product, with the eruption of a rhyolitic tuff in the Burdigalian stage. After a short period of quiet in the lower Helvetian it revives in the middle and upper Helvetian, yielding an agglomerate which at the beginning contains andesitic material but which is held together by a cement of rhyolitic composition. This is succeeded my a magma product of purely rhyolitic nature, changing upwards into andesite again. The II. rhyolite tuff series contains the material of an older, subvolcanic andesite body, not found in our area proper, of as yet unsolved magmagenetic situation and time of origin. The rock genesis connected with the andesite lava commences essentially with a "pseudo-agglomerate" around the middle of the Tortonian, going with some smaller interruptions through the Sarmatian as well. *The growing thickness of the lower and middle Miocene sequence towards the South* with a reduced series in the north, in the foreland of the Nagygalya, and with more differentiated facies around Kékes Peak and the Nagybátony—Salgótarján Basin *shows that the volcanic activity was also shifted towards the SE and S respectively from the Nagygalya center.*

Lava rocks occur in the form of lava flows, ancient neck-like cones (Nyesettvár, Kisgalya, Bagolykő etc.) and dikes. The lava flows are readily distinguished morphologically. In our area there occur two banks of lava of different time of origin. *The lower consists of augitic hypersthene andesite*, situated above the pseudoagglomerate, with predominant phenocrysts of 0,2 to 0,4 millimetres and above, with a proportion of the melanocratic ingredients of 1 : 10 to 1 : 18. (Plate V.). *The upper one is the andesite variety forming the bulk of the Mátra Mountains*, a hypersthenic augite andesite darker and more massive than the lower one, mostly consisting of grains of 0,1 to 0,3 millimetre and below. The proportion of the melanocratic ingredients is intensely variable, augite being always in excess of hypersthene, occasionally with a total lack of hypersthene. *These two banks of lava occur throughout in bodies of NW—SE strike* (Plate VI.).

The andesite dikes are of an extremely variable structure. Their sequence of formation may be deduced from their petrographical features, as follows :

1. The dikes occurring at a higher terrain level can be of two types : a) *the lateral continuation* in a fissure *of the root of a lava flow* ("parasitic volcano", Csór Hill), and b) *the root of a denuded lava flow*, especially in places where there is only the debris of the augitic hypersthene andesite flow left. These two kinds of dike are essentially of the same nature.

c) *The dikes occurring at a lower terrain level* (Fortress Hill of Parádsasvár, Csevice Creek, the court of Rudolf Farm, Aranybányafolyás creek, N and NW side of Nyesettvár) *are*, presumably with the exception of the sulfo and sulfocarbo varieties, *the late products of a residual magma* which have broken out along the lateral fissures of the mountain (Rudolftanya, Nyesettvár). These have generally broken out through or around the rim of the lower lava flow and consist of entirely unaltered minerals. On the other hand, the dikes classed as sulfo or sulfocarbo andesites occur partly in the Neogene sediments (Várhegy ?) and partly in hydrothermally altered andesite (lower lava flow) and its "mantle formation", and their hypo- and metavolcanic features have been caused by the nature of their environment.

The main features of the variable andesite and "mantle" formations of the area will be summarized from the point of view of the new system of E. Szádeczky—Kardoss.

I. The chloritization of the hypersthenic augite andesite forming the upper lava flow is but very rarely observed. This most frequent andesite type of the Mátra Mountains contains as much as 35 to 40 per cent of vitreous ground mass. The feldspars are generally arranged in a fluidal pattern. The plagioclases and pyroxene varieties forming the porphyric ingredients occasionally reach the size of 0,5 millimetre (typical orthomagmatite).

The analysis results and Niggli parameters of the top andesite of Kisgalya Peak are as follows :

Hypersthenic augite andesite cap, Kisgalya				
Nº of sample: 776		Analyst Mrs. K. Guzy		
SiO_2	56,86%	al	=	34,59
TiO_2	0,76	fm	=	32,72
Al_2O_3	18,71	c	=	23,30
Fe_2O_3	1,54	alk	=	9,38
FeO	5,54			
MnO	0,13	k	=	0,45
MgO	3,00	mg	=	0,48
CaO	6,93	O	=	0,13
Na_2O	1,69	si	=	178,9
K_2O	2,12	ti	=	1,79
$+H_2O$	1,80	p	=	0,92
$-H_2O$	0,74	h	=	9,19
CO_2	0,36	c/fm	=	0,76
P_2O_5	0,06			
S	0,07	V. section		
	100,38%			
—O	0,04	peleeitic magma type. Completely identical with data of andesite-labradorite from Ile de Martinique.		
	100,34%			

II. The lower lava flow consists of augitic hypersthene andesite with occasionally some biotite. Texturally and regarding its products of alteration, this is the most variegated andesite type, consisting of the following varieties :

a) Only the *melanocratic ingredients of about 0,1 millimetre* size of the ground mass are chloritized : *hemichloroandesite*.

b) *Hypersthene* is entirely chloritized, *augite* totally unaltered : "*hemichloroandesite*" (?).

c) *All melanocratic ingredients chloritized*, the rock consists of plagioclase, pseudomorphs of chlorite after the dark ingredients and bushy aggregates of chlorite in the ground mass. This kind of alteration is presumably due to transvaporization rather than hydrothermal alteration : *hypochloroandesite* (Plate I.).

d) *The dark ingredients were altered into chlorite with an opacitic rim of magnetite: chloroandesite*.

e) *The one-time dark ingredients are substituted by pyrite and subordinate* *chlorite*. There are two types : 1. Pyrite forms a rim ; the interior of the crystal consists of chlorite : *chlorosulfoandesite*. 2. Pyroxene is entirely substituted by pyrite : *sulfochloroandesite* (Plate IV.).

III. The rock has suffered carbonatization of variable extent.

a) Only the *ground mass* is carbonatized : *hypocarboandesite*.

b) Of the dark ingredients, *hypersthene* is carbonatized, eventually together with *augite: carboandesite*.

c) *Leuco- and melanocratic ingredients* are both carbonatized (mostly in dikes or along hydrothermal fissures) : *metacarboandesite*.

d) *Feldspars* are carbonatized, the ground mass consists of chlorite (mostly in case of andesite dikes) *chlorocarboandesite*.

e) The magmatic ingredients are wholly substituted by *all three* of the epigenetic minerals (only in hydrothermally altered areas) : *chloro-carbosulfoandesite*.

f) *Feldspars* are altered only. This rock type is most frequent in the ore-bearing silicified zones of lava and tuff rocks : *hydroandesite* and "*hydropyroclastite*" (pseudotuff).

g) A rock variety by itself is the *augitic hypersthene andesite* containing nodes of light blue, pale greenish-blue chalcedony, corresponding to a *chalcedonous chloroandesite*.

h) The body of intensely altered, rounded lava rubble occurring on the rim of Nagygalya and Csórhegy are relegated to the *pseudoagglomerates*. The varieties of spherical fissuring and "tuffy" cement (as e. g. below Bagolykő and Csórhegy Peaks) were also relegated to this group.

Volcanic dikes

1. *Carboandesite of Csevice Valley, Parádsasvár*. The rock consists of two ingredients : an iron-bearing calcite related to siderite, occurring in a proportion of about 35 to 40 per cent, of fine feldspar laths of about the same amount, and of fine chlorite aggregates in the ground mass. The carbonate content shows a variance in the lateral sense. Towards Kislipót the dike is developed in a type much resembling the "hybride andesite" described by G. P a n t ó from Gyöngyösoroszi : it contains lens-shaped oriented inclusions of calcite, and rarely of quartz. According to P. K r i z s á n, its chemical composition and Niggli parameters are as follows :

Carboandesite dike, Csevice Creek, Parádsasvár

Analyst P. K r i z s á n

SiO_2	56,30%	al	=	27,5
TiO_2	1,00	fm	=	33,7
Al_2O_3	16,00	c	=	21,7
Fe_2O_3	9,00	alk	=	14,5
MnO	0,14			
MgO	3,62	si	=	164,10
CaO	6,87	ti	=	2,3
Na_2O	3,65	c/fm	=	0,64
K_2O	2,35	IV. section		
$+H_2O+CO_2$	1,20	normal dioritic magma type		
	100,16%			

The hypoparallel dikes of the Fortress Hill of Parádsasvár, consisting of chlorocarboandesite with all melanocratic ingredients altered, occurring in the Chattian sandstone, differ from the previous rock type inasmuch as they are of a characteristic intergranular texture. Between laths of intermediary to basic feldspar there are nodes of chlorite and of a carbonate resembling siderite. The texture very much resembles that of the pyroxeneless diabases of the Darnó Hill, with a significant difference, however, in chemical constitution. The Várhegy chloro-carboandesite is composed, according to analyst E. Donáth—Pécsi, as follows:

SiO_2	53,08	al	=	28,4
TiO_2	1,28	fm	=	33,0
Al_2O_3	15,64	c	=	23,0
Fe_2O_3	3,84	alk	=	15,5
FeO	0,71	si	=	175,7
MnO	0,19	ti	=	3,2
MgO	4,59	k	=	0,28
CaO	6,51	mg	=	0,68
Na_2O	3,49	c/fm	=	0,70
K_2O	2,09			
$+H_2O+CO_2$	5,74	normal dioritic magma type related to the pyroxene-mica diorite of Electric Peak		
$-H_2O$	0,86			
P_2O_5	1,93			
	99,98%			

2. *Andesite dikes of basaltic appearance (Rudolftanya, Nyesettvár, and highway between Mátraszentimre and Nagygalya).*

The dike of 330°—150° strike and of some 25 metres width in the court of Rudolftanya Farm apparently occurs at the boundary of the lower (kaolinitized) lave flow and the kaolinitized II. tuff horizon. It can be followed in a length of 50 metres. The rock is of an exceedingly fine-grained, massive texture and of basaltic appearance. Under the microscope it resembles a feldspar basalt. The ground mass consists of a fine mesh of feldspars, with some porphyric feldspar grains and hypersthene and augite inclusions of pea size. The feldspar crystals of "trachytic" arrangement flow around the porphyric ingredients, which make up no more than 10—12 per cent of the rock (microandesite ?). The porphyric feldspars are somewhat sericitized, and their extinction shows them to be of an Ab_{30}—An_{70} composition. The small feldspar laths (10—20 ?) appear to be bytownitic in constitution. The vitreous ground mass is about 60 per cent.

The small spot of rock of basaltic appearance below the Nyesettvár Peak is not of a homogeneous consistency: it has a wholly vitreous variety and another one showing lathy jointing.

The vitreous variety, consisting of a vitreous mass in its bulk, contains some plagioclase laths, chloritized melanocratic ingredients, pyrite and magnetite.

The non-chloritized melanocratic ingredients are hypersthene and sometimes augite. The latter is diopsidic and in some instances titanaugite. There is a quite subordinate amount of occasional olivine grains, subject to partial serpentinization. The labrador and bytownite feldspars may contain inclusions of pyroxene and other minerals.

The other variety, of the lathy jointing, is similar in composition, with somewhat less of vitreous and chloritized ground mass and more of plagioclase in hypoparallel arrangement.

Vitreous andesite dike, Rudolftanya

Analyst Mrs. K. Guzy

SiO_2	58,48%	al	=	27,28
TiO_2	1,12	fm	=	12,07
Al_2O_3	17,80	c	=	17,76
Fe_2O_3	0,86	alk	=	9,45
FeO	5,83			
MnO	0,01	si	=	150,4
CaO	6,45	ti	=	2,17
MgO	2,05	p	=	0,23
Na_2O	2,70	h	=	0,25
K_2O	1,66	k	=	0,29
$+H_2O$	2,83	mg	=	0,39
$-H_2O$	0,70	O	=	0,82
CO_2	trace	c/fm	=	0,8
P_2O_5	0,21	V. section		
	100,70%			

3. In the bed of the *Aranybányafolyás creek* there occur a number of dikes which can be distinguished from the surrounding rock macroscopically as well as microscopically. These dikes are of a general NW—SE strike; however, there are exceptions to that.

The dikes contain no melanocratic ingredients at all, the latter being generally replaced by pseudomorphs of pyrite. The feldspars are partly porphyric, 0,1 to 0,5 millimetres in size, of labradorbytownite composition, partly replaced by carbonates. The plagioclases of the ground mass are andesitic and occasionally of even more acid constitution (carbo-sulfo andesite). Such dikes also occur in the bed of Lipótfolyás Creek below the new Keepers' house of the Nyirjes.

Vitreous andesite of basaltic appearance, Nyesettvár

Analyst Mrs. K. Guzy

SiO_2	53,37%	al	=	25,49
TiO_2	1,16	fm	=	29,32
Al_2O_3	18,26	c	=	20,06
Fe_2O_3	2,83	alk	=	10,36
FeO	6,79			
MnO	0,01	si	=	123,00
CaO	7,91	ti	=	2,07
MgO	3,06	p	=	0,21
Na_2O	3,26	h	=	0,14
K_2O	1,90	k	=	0,28
$+H_2O$	1,47	mg	=	0,44
$-H_2O$	0,36	o	=	0,21
CO_2	0,10	c/fm	=	0,68
P_2O_5	0,21	V. section		
	100,69%	Ossipite-gabbroidic magma type		

4. *The dike occurring in the part of Aranybányafolyás intersecting the great silicified zone of the Nyirjes* contains 7,99 per cent of pyrite. The carbo-andesite forming the rim of this dike contains porphyric plagioclases of 2—3

Pyritized rock dike, Aranybányafolyás

Analyst Mrs. K. Guzy

SiO_2	58,63%	al	=	36,08	
TiO_2	0,66	fm	=	30,79	
Al_2O_3	18,30	c	=	20,05	
Fe_2O_3	0,61	alk	=	13,07	
FeO	5,59	si	=	196,3	
MnO	0,06	ti	=	3,6	
MgO	2,70	p	=	0,85	
CaO	5,60	k	=	0,42	
Na_2O	2,23	mg	=	0,46	
K_2O	2,60	o	=	0,05	
$+H_2O$	2,20	c/fm	=	0,62	
$-H_2O$	0,37	k	=	66,6	
CO_2	0,16				
P_2O_5	0,06	IV. section			
S	1,43	Peléeitic magma type,			
	101,20%	andesite, Mont Pelée			
—O	0,72				
	100,48%				

millimetre size, forming 25 to 30 per cent of the rock. The feldspars are partly carbonatized (the carbonate being related to siderite), and the fissures are filled by pyrite. The ground mass consists to about 70 per cent of a felsitic web with much pyrite and scarce magnetite.

Silicified andesite nests

The lower lava flow contains around the Nagylipót as well as around the ore-bearing area of the Nyirjes some black to greenish-black silicified nests of variable size and fist-sized nodes which pass gradually into the apparently fresh surrounding rock. They are much more frequent between Nyirjes and Kövesorom then around Nagylipót and Nagylápafő. *These are more intensely differentiated parts of andesite*, having undergone a silicification of greater intensity, *rather than the results of hydrothermal processes*. The ground mass is no amorphous rock glass, but an aggregate of mostly crystalline quartz, eventually of a SiO_2 variety teending towards the chalcedony state, in which there occur porphyric grains of disseminated hypersthene, augite and plagioclases of andesinic-labradoric constitution. The ratio augite-hypersthene is 1 : 10. Beside pyroxene there is much magnetite and lots of pyrite.

Hydrothermal rock varieties (endometavolcanites)

In the investigated area the above-named rock types enjoy a great vertical and horizontal extension and according to the observations hitherto made they are restricted to the horizon of the middle rhyolite tuff and the lower lava flow. The upper lava horizon was not touched by this hydrothermal influence ; this circumstance serves to delimit the time of origin of the ore formation.

The decomposition and alteration of the rocks is most intense in the ore-bearing and silicified zones ; in these areas it was not nearly possible, even by microscopic investigation, to map apart the lower lava flow and the "mantle formation", partly of rhyolitic, partly of andesitic nature, connected with the middle rhyolite tuff.

The most intense decomposition has occurred below Nagygalya Peak (between Kövesorom and Péterhegy), at the Rudolftanya farm, at Nagylipót, Nagylápafő, Nyirjes, Aranybányafolyás, as well as on the southern rim of Nagyszarvasfolyás and Nagybikk.

The decomposition manifests itself in a total alteration of siallic as well as femic constituents. After a first initial sericitization the minerals have undergone kaolinitization, and subsequent carbonatization, while the dark ingredients were mostly altered into chlorite and into pyrite pseudomorphs. The formation of oxy varieties occurred but very seldom.

A montmorillonitization of the siallic ingredients in a basic medium can at present be observed only in the environment of Csórhegy Hill, where there occur nodes above fist size of "Fuller's earth" in "pseudoagglomerate" and in the upper parts of the II. tuff horizon. It seems that south of Csonkabérc, toward Asztagkő Peak, the decomposition has gone on in a similarly basic medium, as in this direction the occurrence of montmorillonite becomes increasingly frequent, and around Asztagkő there are already bentonite lenses and bodies of greater extension in a baryte-rich surrounding (as in the court of Asztagkő quarry).

1. The totally decomposed *carbonatized rock* around the Nagylipót (dacite according to F. P a p p) is of a microcrystalline texture with the outlines of the ancient porphyric feldspars (Plate III). There are not even traces of dark ingredients left. The plagioclases are substituted by sericite, pyrite and eventually by quartz. Some of the feldspars, substituted by sericite and kaolinite, exhibit traces of polysynthetic twinning, indicative of intermediary to basic chemical composition, so that the rock could not even originally be a dacitic or even more acid lava product. The traces of the ancient dark ingredients have the characteristic oblong shape of hypersthene, indicating that the rock originally belonged to the augitic hypersthene andesite of the second lava flow.

This same assumption is corroborated by the analysis results of J. M e-z ő s i and E. D o n á t h—P é c s i, proving the rock to be andesite.

2. In the *Aranybányafolyás—Nyirjes area* the decomposition is even more intense than in Nagylipót and Nagylápafő. Intense kaolinitization has totally erased the individuality of the rocks corresponding to the lower lava flow and the second tuff horizon. However, the presence and hydroandesitic development of the lower lava flow could be demonstrated with certainty in the well dug in the court of the Nyirjes Keepers' house.

The analyzed rock was found at the deepest part of the Aranybányafolyás valley, at a point falling within the ore-bearing zone. According to its location, it belongs to the bedrock of the decomposed upper lava flow (hydroandesite) where similarity in decomposition makes impossible to define the limit of the two formations. The microscopic and chemical analyses have indicated the presence of a rhyolitic magma product belonging to the second tuff horizon, with a remarkable potassium content. Beside its sericite and hydromica content, the rock also carries much kaolinite, as contrary to the usual process of hydrothermal alteration, so that, although not fully proven as yet, a potassium metasomatism of some sorts may be assumed here.

	%
SiO_2	57,70
TiO_2	0,71
Al_2O_3	18,89
Fe_2O_3	1,99
FeO	2,36
MgO	0,08
CaO	6,11
Na_2O	3,75
K_2O	1,58
$+H_2O+CO_2$	3,75
$-H_2O$	0,35
P_2O_5	1,62
	99,98

3. *Above the "Lajos" Keepers' house*, in the landslides and eroded gullies of the Nagybikk, there occurs an *intensely kaolinitized rock* of dacitic appearance with locally some quite fresh hypersthene crystals, while the ground mass and the porphyric feldspars were altered into a submicroscopic kaolinitic

Hydrothermally decomposed yellow-white "hydroandesite" (?), Aranybányafolyás
Analyst Mrs. K. Guzy

	%			
SiO_2	57,76	al	=	31,01
TiO_2	0,84	fm	=	8,75
Al_2O_3	19,29	c	=	1,14
Fe_2O_3	6,41	alk	=	20,54
FeO	0,13			
MnO	trace	si	=	157,60
CaO	0,39	ti	=	1,70
MgO	0,46	p	=	—
Na_2O	2,62	h	=	0,39
K_2O	7,82	k	=	0,66
$-H_2O$	0,93	mg	=	0,06
$+H_2O$	3,31	O	=	0,61
CO_2	—	c/fm	=	0,12
P_2O_5	trace	II. section		
	99,96			

mass. The minute, intricate pores of the rock are filled by idiomorphic and bud-shaped hematite. This rock is a hydroandesite. *The dark ingredients seem to be unaffected by pure kaolinitic decomposition, undergoing alteration only in the presence of hydrogen sulphide and carbonatic solutions* (Plate II.).

4. *Between Aranybányafolyás and Kisgalya*, on the rim of a nose jutting-out below Nagyszarvasfolyás, a tuff is encountered with more or less fresh biotites and cavities of several centimetres size, lined with quartz. It contains also rounded lapilli of bean size. The undecomposed feldspars occurring here

and there are oblong crystals of sanidine and extremely acid plagioclase. The idiomorphic quartzes of the cavity fillings replace pumice. These features prove the rock to be a rhyolitic magma product, corresponding to the middle rhyolite tuff.

Ore genesis

The delimitation of the ore-bearing zones of the area was performed by the simultaneous application of surface observations and geochemical methods. The latter consisted in an application of the dithisone micro-reaction method and of the trace element analysis of the ashes of plants, e. g. of moss.

Dithisone, particularly sensitive to Pb, Zn and Cu, has yielded a positive reaction especially with the waters of springs and creeks of two drainage areas, namely that of Csevice Creek below Nagylápafő and Nagylipót and of Lipótfolyás and Aranybányafolyás. The ashes of moss growing on the silicified outcrops of both Nyirjes and the Nagylipót environment (e. g. Eurhynchium zetlerstadtii, Plagiochile aspernoidai, Dicranum scoparium, Istohercium riviparum), were found to contain lead by a microchemical reaction, and cobalt, titanium and chrome by spectral analysis (I. K u b o v i c s).

Silicified outcrops are concentrated in two greater areas : Nagylipót and Aranybánya—Nyirjes. However, there occur a number of silicified specks of variable size elsewhere : below Nagygalya, between Péterhegy and Körösnyaktető, in a zone of the Nyirjes crest below the 795 metre point, in a number of places along Nyirjesi-folyás and Lipótfolyás, in a greater outcrop below Nagyszarvasfolyás, on that side of Körösnyaktető and Nagybikk which looks down the Szénpatak valley, and in scattered outcrops below Nyesettvár, in the creek bed below Rudolftanya Farm, in the bed of Csevice creek and between Nagylápafő and Vércverés. The latter are considered to be alluvial boulders and scree.

In lack of appropriate outcrops it was impossible to define a vein-like or other shape of the geological bodies, of which the silicified blocks are parts. The occurrence of the silicified outcrops at different terrain levels and along a definite strike line suggest some veins of steep dip, delineating two more or less parallel tectonical directions :

a) of a NW—SW strike connecting Kövesorom and Nagylipót, Peaks,

b) pointing towards Nagygalya along the Nagyszarvasfolyás—Aranybányafolyás line.

c) It may be further assumed, although the necessary exposures are lacking, that the line Mátraszentimre—Körösnyaktető—Asztagkő forms a separate unit. This area will necessitate further research.

The outcrops indicate that the two firstnamed "ore fields" consist of several "vein-like zones", probably connected by transversal "veins" of "reduced" thickness. The development of this pattern made possible by the intensely decomposed rock of the II. lava bank and of the middle rhyolite tuff, wherein vein- and dike-like formations of variable strike, or eventually of a cobweb pattern, could have formed as well as silicic impregnations of no particular strike.

1. In the *Nagylipót* and *Nagylápfő* area the outlines of at least three veins are apparent, the two lateral ones being of NW—SE strike, while the direction of the central one is uncertain. The lateral "vein" at the foot of

Kislipót is partly of a brecciated texture, with mostly dark-grey ore of colloid grain size. In some parts of the vein chalcedony and liver opal of greyish tint was encountered. Predominating minerals are pyrite, chalcopyrite, galena, sphalerite and native gold. The latter occurs seldom in pyrite, more frequently in the form of independent disseminations. (Gold was demonstrated by the B ü r g process, keeping the polished rock surface in a furnace at 700 centigrades for several hours, whereby the gold is left unchanged after the oxidation of all the sulphide ores.)

An analysis of the material of the surface outcrop has yielded the following results (J. C z i b u l k a, Laboratory of Recsk Ore Mine) :

			%
I.	Pb	=	0,23
	Zn	=	0,30
	Cu	=	trace
	Fe	=	4,45
II.	Pb	=	0,10
	Zn	=	0,40
	Cu	=	0,10
	Fe	=	4,09
	Au	=	2,07 gr/t
	Ag	=	5,50 gr/t

The sulfides occur disseminated in insulated nests ; their interrelation and sequence of formation cannot be determined. The mineral containing the silver indicated by analysis could not be demonstrated as yet. The lime-yellow dust occurring on the surface of "ore-rich" rock parts is presumably a Pb—Zn ochre. I. K u b o v i c s has found in this dust beside Pb and Zn some silver, copper, arsenic and titanium as well. The presence of arsenic suggests tetrahedrite, presumably carrying the demonstrated silver. Tetrahedrite was found up to now only in the ore-bearing silicified rock below Nagygalya, in minute amounts beside chalcopyrite pyrite and galena (Plate XII.). In the two other "vein" zones of Nagylipót a weak pyrite dissemination was found with subordinate chalcopyrite. Beside the gangue minerals hematite, idiomorphic quartz and sorts of chalcedony and opal, indicated already by F. P a p p, we have also found amethyst.

The chemical composition of grey, massive vein rock is (according to Mrs. K. G u z y, Analyst) :

	%
SiO_2	97,60
TiO_2	0,90
Al_2O_3	1,51
Fe_2O_3	0,26
FeO	0,12
Ign. loss	0,09
	100,48

2. *Nyírjes—Aranybányafolyás.* The vein rock of this area differs from that of the Nagylipót ore field inasmuch as in the cavities there occur phenocrysts of transparent quartz of 3—4 centimetre size, with the (hOhl) rombo-

hedron and (10$\bar{1}$0) prism faces. Some of the quartzes are amethyst, rose quartz and sceptre quartz varieties.

The higher degree of crystallinity of the vein rock is apparent, although there occur also massive microcrystalline varieties resembling the Nagylipót rock. The analysis data of the vein rock are according to Mrs. K. Guzy:

	%
SiO_2	93,20
TiO_2	0,68
Al_2O_3	3,92
Fe_2O_3	0,55
FeO	0,34
Ign. loss.	0,02
	98,71

The mineral constitution is exceedingly variable.

Ore minerals:

native gold	Au
chalcopyrite	$CuFeS_2$
pyrite	FeS_2
galena	PbS
sphalerite	ZnS
tetradymite	Bi_2Te_2S
bismuthite	Bi_2S_3
tellurite (tellurium ochre)	TeO_2
native tellurium	Te
goethite	FeOOH

Gangue minerals:

quartz	SiO_2
baryte	$BaSO_4$
calcite	$CaCO_3$

Native gold is quite subordinate, it was up to now demonstrated exclusively in the debris of silicified vein rock in the Aranybányafolyás creek bed.

Most frequent ore minerals are chalcopyrite and pyrite, with subordinate sphalerite and galena. Here chalcopyrite is the first formation, while sphalerite and galena are younger. The relation of gold to pyrite and chalcopyrite, respectively, is unclear ; up to now, gold was found in insulated grains.

The bismuth tellurides, which were up to now, according to K. Sztrókay and S. Koch, found only at Nagybörzsöny (Börzsöny Mountains) and Zsubkó (Slovakian Ore Mountains) within the Carpathian Basin (15), were given a detailed treatment. They show no connection at all with the rest of the sulphides. Up to now they were found only in the large quartzite blocks cropping out around Nyirjesi-folyás.

Tetradymite (Bi_2TeS) occurs in steel-grey aggregates of plates and grains of 0,8 millimetre and smaller size in dove-gray massive quartzitic vein rock. On the bigger plates the sheaf-like arrangement of minute flakes according to (0001) is visible even to the naked eye. The smaller flakes make, because of the bluish tint of their surface colouring, a molybdenite-like impression. Under the ore microscope the mineral is white with a yellowish hue. It has a greyish-white, slightly greenish light-grey pleochroism, especially apparent when contrasted with adjacent bismuthite. Its colour of anisotropy is yellowish-brown-grey, more apparent under oil immersion. On the base face the reflection intensity is somewhat smaller and the mineral appears to be entirely isotropic. The gangue along the rim of greater crystals is, as it were, "imbued" with tetradymite, containing a multitude of idiomorphic crystals, the cleavage flakes of which were in some instances shifted in a cardpack-like manner. (Plate XI.)

In some of the tetradymite fields occur islands of bismuthite, of smaller reflection intensity and of a comparatively grey tint, arranged parallel to the long axis of the tetradymite crystals. Bismuthite is white with a slightly bluish pleochroic hue. Pleochroism is more readily observed along the rim of the grains : it is white, to light grey ; creamy white to greyish white in oil immersion. Between crossed nicols, anisotropy is intense but not of a vivid colour. In oil it is a much more vivid grey, greyish brown, with a greenish-yellow tint in some instances. Cleavage plates according to (001) are clearly visible, extinction is straight as related to this cleavage. Bismuthite is somewhat harder than tetradymite, wherefore its grains are of sharp outlines. In some cases the outlines are vague and the mineral shows a myrmekitic intergrowth with tetradymite. (Plates VII, VIII, IX, X.)

Beside bismuth, tellurium and sulfur the microchemical study has also yielded antimony, while a spectral analysis by Mrs. A. F ö l d v á r i has demonstrated Sn and Mo as well.

The X-ray pattern data of tetradymite are shown in the following table :

Tetradymite, Nyirjes X-ray analysis by Mrs. E. G y ő r e		Tetradymite, Zsubkó, Banska Štiavnica Mine District, Slovakia	
Int.	d_{hkl}	Int.	d_{hkl}
—	—	20	5,20
—	—	70	4,72
w	4,584	—	—
w	3,560	20	3,57
w	3,366	50	3,38
—	—	20	3,20
xx	3,054	100	3,04
—	—	20	2,72
vvw	2,644	50	2,63
vvw	2,471	50	2,50
w	2,401	50	2,42
x	2,256	100	2,26
—	—	70	2,14
m—x (d)	2,099	70	2,08
—	—	60	2,05
w	1,921	70	1,91
vw	1,799	20	1,81
m (d)	1,734	50	1,73
m	1,652	70	1,63
—	—	50	1,59
m—w (d)	1,549	70	1,55
vvw	1,493	20	1,49 (d)
m (d)	1,428	70	1,43 (d)
w	1,368	20	1,38
m	1,343	50	1,34
m	1,291	90	1,29
w (d)	1,254	70	1,25
vw	1,222	20	1,23
w	1,207	70	1,20
vw	1,181	20	1,18

xx = very strong, x = strong, m = medium-strong, w = medium, vw = weak, vvw = very weak, (d) = diffuse line

The most intense lines bismuthite, at 3,50, 2,08 and 1,93 are lacking; however, some diffuse lines are coincident with lines of bismuthite. This is explained by the predominance of tetradymite and the subordinate role of bismuthite: the lines of the latter are suppressed or overshadowed by the intense lines of tetradymite.

In cavities besides tetradymite and bismuthite there occur also yellow to lemon-yellow dusty cavity fillings. These contain locally some black, metallic-looking, minute crystal splinters invisible to the naked eye, from which only tellurium could be demonstrated. The microchemical study of the yellow dust has yielded Te, Pb, Sb and Bi. A spectral analysis by I. Kubovics has further proven the presence of the following elements:

V	Cr	Ti	Ni	Co	Cu	Mo	Sn	Mn	B
+	tr	tr	tr	tr	+	(tr)	(tr)	tr	++

The presence of strong traces of vanadium and of volatile boron is rather unexpected.

Thus, the lemon-yellow dust is a sort of mixed ochre with tellurium ochre (tellurite) and native tellurium for main ingredients. The evaluation of the X-ray pattern of the Nyirjes ochre proves the presence of tellurite.

In stibnite, occurring in the court of the Asztagkő quartzite quarry, we have demonstrated microchemically with certainty the presence of tellurium, although ore microscopical analysis has revealed no tellurium mineral.

Let us note that stibnite occurs there in two generations, *a)* in independent greater crystals mostly incrusted by yellow antimony-ochre, cervantite, and *b)* in minute needles within marcasite, with the surface of the marcasite transformed into idiomorphic pyrite (Plate XIII).

At two points of the area (see map), some 800 to 900 metres west of Rudolftanya Farm, and in the bed of Aranybányafolyás Creek, below the bridge of the cart-track to Nagybikk, there occur incrustations and infiltrations consisting of oxidic manganese ore (wad-pyrolusite) indicating the proximity of orebearing zones.

The "manganese ore" at Rudolftanya was disclosed by a newly-built forest road and was found to be a local enrichment of restricted extension. The "ore" occurs at two levels: it forms *a)* a cobweb-like pattern in the kaolinitically decomposed lower lava bank and *b)* a redeposited layer of 5 to 15 centimetres thickness immediately below the soil. Its chemical composition is ideally close to formula, with however, no practical significance.

Manganese ore

Analyst Mrs. K. Guzy

	%
MnO_2	57,16
CoO	0,03
NiO	0,04
V_2O_5	trace
$-H_2O$	5,69
$+H_2O$	10,73
insolubles	8,55

The dark incrustations of the Aranybányafolyás environment contain chemically demonstrable amounts of vanadium ; on the other side, the manganese content is less than one tenth of the former ore.

	%
MnO_2	3,39
CoO	0,04
NiO	trace
V_2O_5	0,02
FeO_3	7,46
TiO_2	0,67
$-H_2O$	3,57
insolubles	68,75

Ore mineralogical evaluation and practical significance of the area

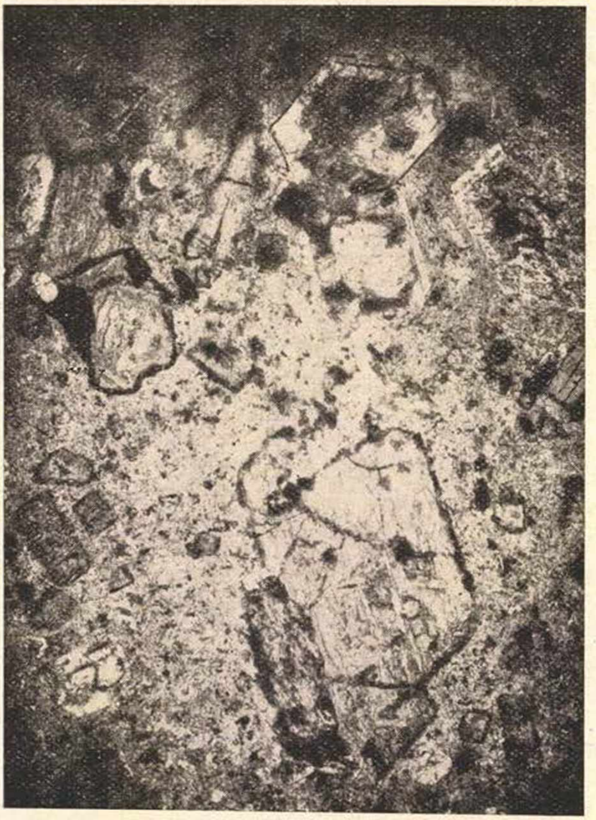
The ore formations of the Mátra Mountains occur in two areas, namely, a western (Gyöngyösoroszi) and an eastern one (Recsk). *Their elemental associations are essentially identical, the quantity proportions of the elements, the mineral associations and history of formation being, however, totally different.* From the investigations of K. S z t r ó k a y, the following elemental distribution emerges for the two Mátra Mountains ore regions :

E-Mátra	Recsk	predominating :	Cu, Au, Ag (S, Se)
		subordinate :	Pb, Zn, Bi
		spectral :	Sn
	Darnó	predominating :	Cu
		spectral :	Pb, Zn, Sr
W-Mátra	Nagygalya	predominating :	Pb, Zn, Cu
	Nagylipót	predominating :	Cu, Zn, Pb, Au
		subordinate :	F, Ba
	Nyirjes	predominating :	Bi, Te, Zn, Pb, Cu
		subordinate :	Sb, Ba
		spectral :	Sn, Mo, B, V
	Asztagkő	predominating :	Sb, Zn, Pb, Ba
		subordinate :	Cu, Fe
	Gyöngyösoroszi	predominating :	Zn, Pb (Cu)
		subordinate :	Au, Sb, Sr, Ba (F)

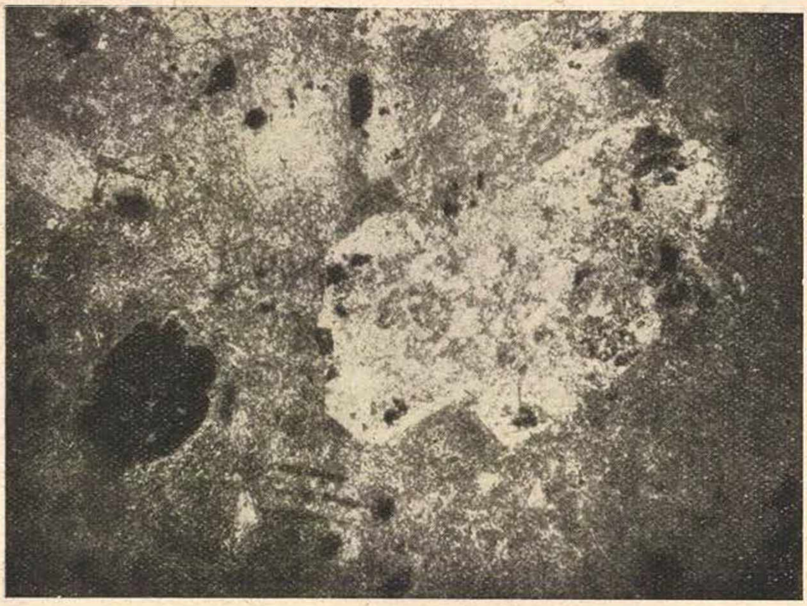
The elemental association indicates that the area described above occupies a *transitory situation* between the Recsk and Gyöngyösoroszi "ore centres", although both its ore genetical and geochemical features tend to relegate it to the Gyöngyösoroszi "system". This remarkable circumstance is — in the author's opinion — due to tectonical causes. The Eastern Mátra zone lies between the points Parádsasvár—Parád—Recsk and the Darnó thrust line, above a downthrown Meso-Palaeozoic basement of entirely different constitution, connected with the Bükk Mountains. On grounds of analogies from the Darnó Hill and the Bükk Mountains, the ore of the Palaeogene volcanites (Recsk and environment) seems to *reflect*, as it were, *the ore formations of a deeper-seated basic magma product.*

The ore zone of the Western Mátra Mountains was developed along a fissure system transverse to the thrust line of the Darnó Hill. It widens significantly where the two systems of structural lines seem to meet. The greater independent lava masses of Nagygalya, Csórhegy and Kékes etc., were likewise formed at similar intersections. The Zn, Pb, Sb, Te, Bi, Ba, F association of the Western Mátra ore region indicates a connection with an acid to neutral magma. From this circumstance, as well as from the presence of granite xenoliths in the Gyöngyössolymos rhyolite, the conclusion follows that the western ore zone overlies a basement consisting partly or entirely of "Palaeozoic", "Praepalaeozoic" acid intrusives (Vepor Mountains). The different chemical nature of the western and eastern ore formations is due, in our opinion, to the fact that they carry the elements, mobilized (regenerated) by Tertiary volcanism, of the ancient ore formations of two different types of basement. This is apparently corroborated by radioactivity measurements (verbal communication), showing a recognizable peak around the western ore zone and none around the eastern one (Fig. 1).

EXPLANATION OF PLATES



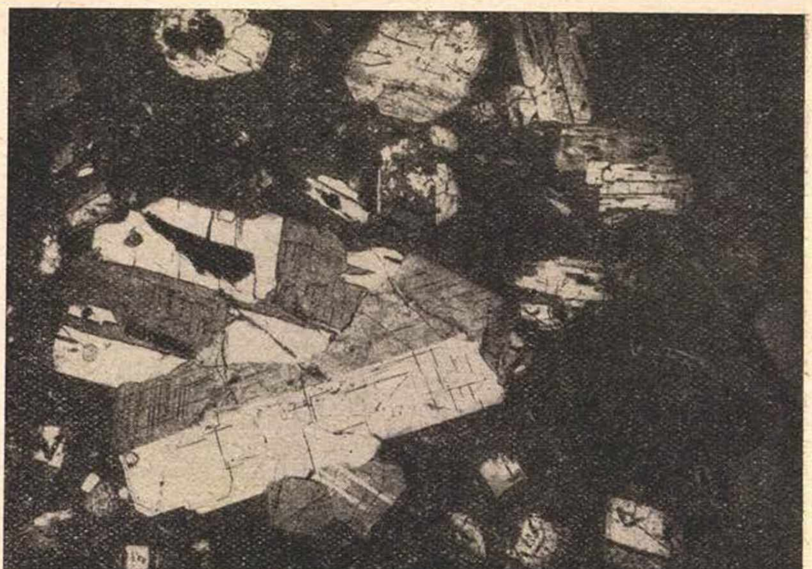
I. Chloroandesite. Hypersthenes and augites turned totally into chlorite. Aranybányafolyás. + N, 22,5x.



II. Hydroandesite. In the ground mass of pure kaolinite the outlines of feldspars are only visible. Hypersthenes are fresh. Nagybikk N, 22,5x.

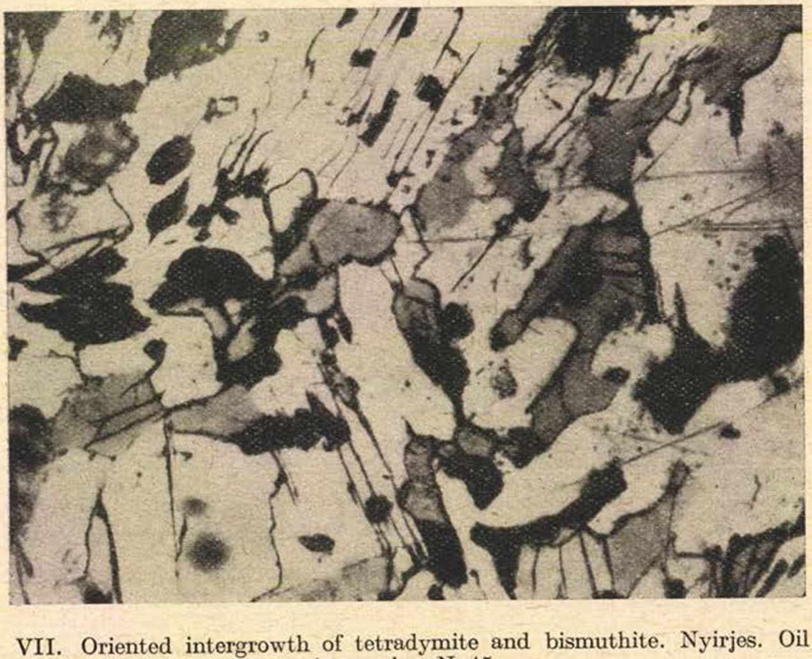
III. Hydroandesite. The outlines of one-time feldspars and dark ingredients are visible in the kaolinitic ground mass Nagylipót—Nagylápafő. N, 22,5x.

IV. Sulfochloroandesite. The independent aggregates of pyrite and its pseudomorphs after dark ingredients are conspicuous. Aranybányafolyás N, 22,5x.

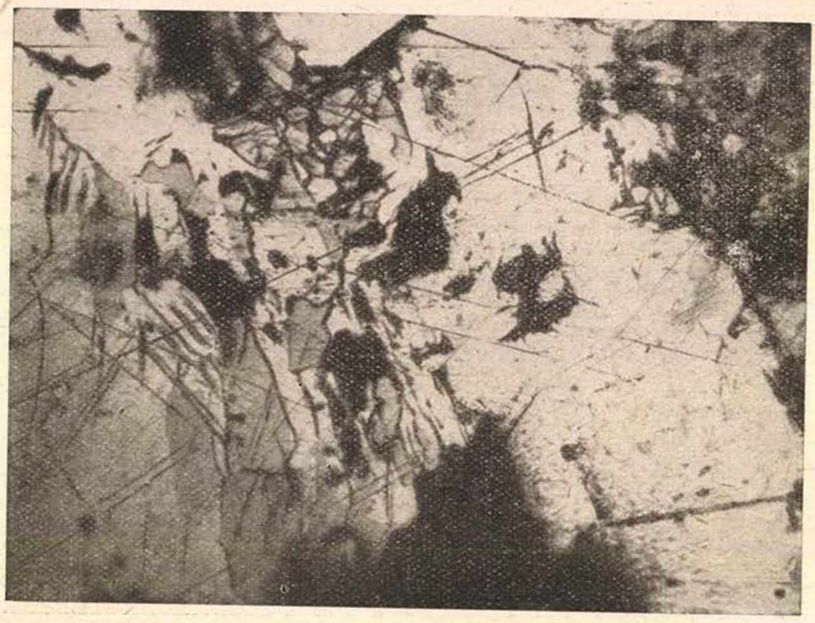


V. Texture of lower lava flow. Kisgalya, +N, 22,5x.

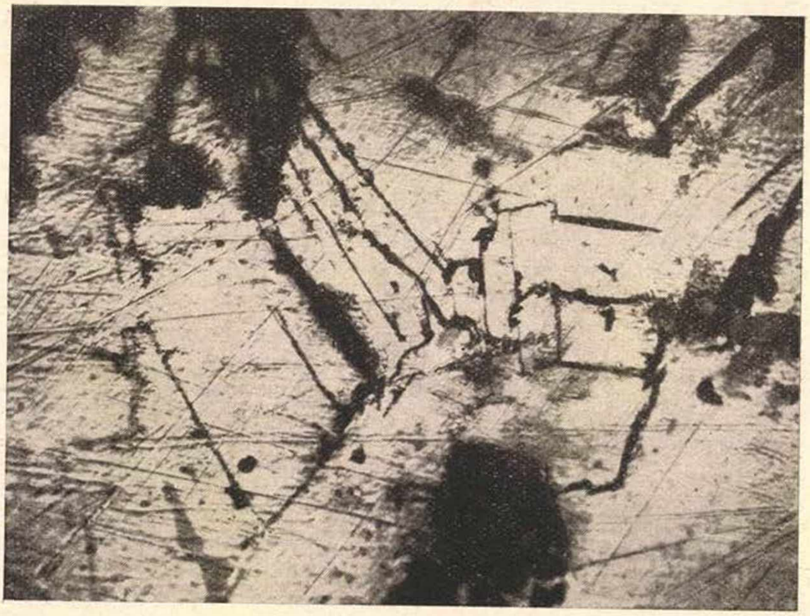
VI. Texture of upper lava flow. Kisgalya, +N, 22,5x.



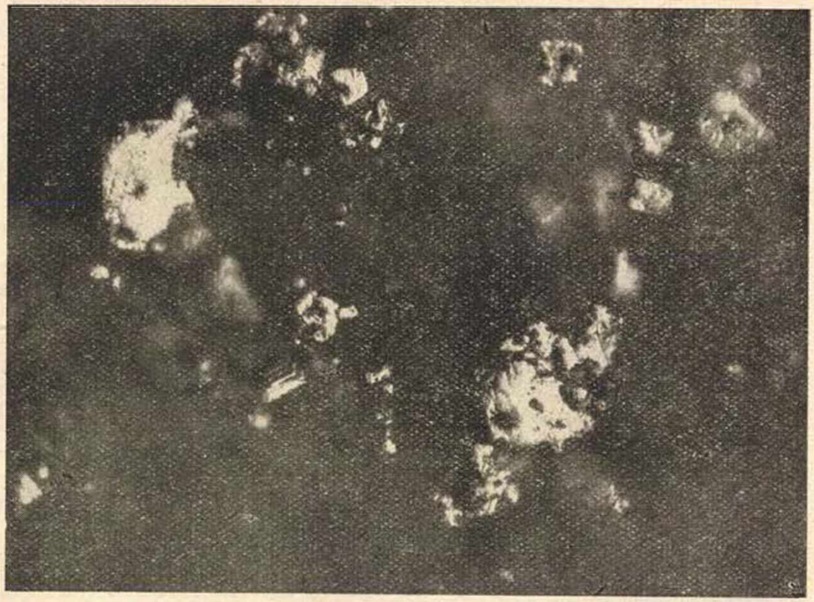
VII. Oriented intergrowth of tetradymite and bismuthite. Nyirjes. Oil immersion, N, 45x.



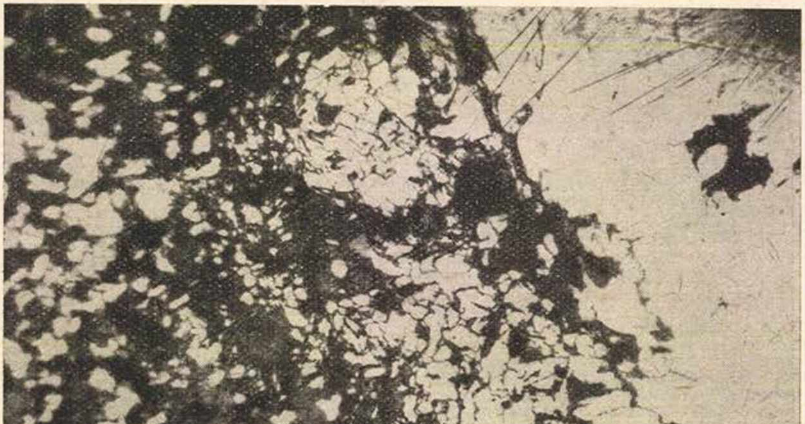
VIII. Oriented intergrowth of tetradymite and bismuthite. Nyirjes. Oil immersion, N, 45x.



IX. A cardpack-like arrangement of cleavage flakes of tetradymite. Nyirjes. Oil immersion, N, n4 45x.

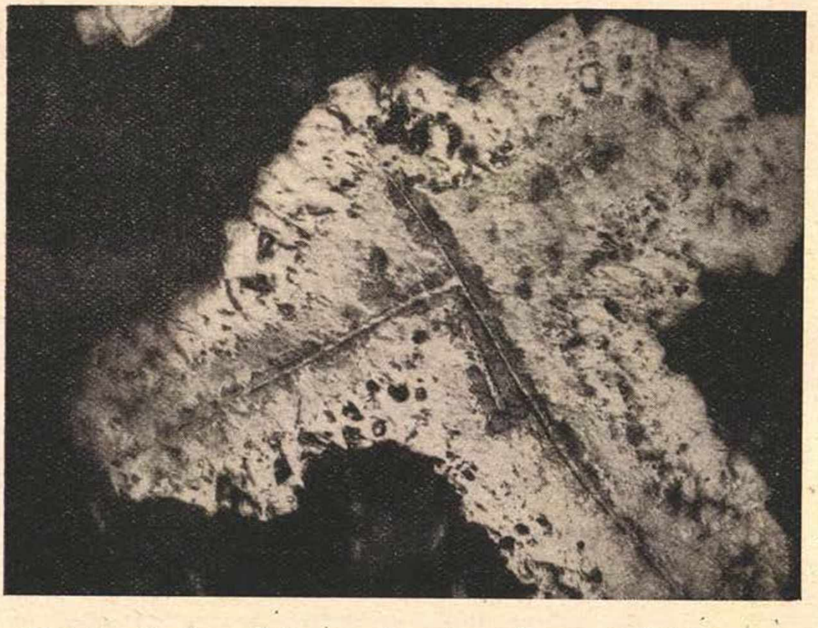


X. A sponge-like network of tetradymite crystals in a quartzite matrix (black). Nyirjes. Oil immersion, N, 45x.



XI. Independent nests of chalcopyrite in vein quartz. Aranybányafolyás. N, 45x.

XII. Disseminated pyrite and chalcopyrite. Nagylipót. N, 22,5x.



XIII. An stibnite needle in marcasite, with pyrite crystals lining the rim of marcasite. Asztagkő. Oil immersion, N, 180x.

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